Effects of Age, Sex, and Duration of Postmortem Aging on Percentage Yield of Parts from Broiler Chicken Carcasses

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ABSTRACT The objective of this study was to evaluate effects of age, sex, and postmortem carcass aging duration on parts yield from broiler chickens. Two hundred twenty-four mixed-sex broilers were reared under commercial-like conditions for various periods between 37 and 51 d, slaughtered, packed in ice, and then aged for 0, 2, 4, or 6 h. Mean percentage yield of thighs, drumsticks, forequarters, wings, breasts, and filets were evaluated for each rearing period, sex, and postmortem aging duration. Yield of meatier parts such as thighs, forequarters, breasts, and filets increased with birds' ages. Female carcasses produced higher percentage yields of forequarters, breasts, and filets but lower yields of drumsticks. Carcasses aged 2 h or more postmortem tended to have lower yields of forequarters, breasts, and drumsticks than did carcasses aged for shorter durations. No statistically significant interactions among age, sex, or postmortem aging duration that affected yield of parts were detected. This information is useful to integrated poultry firms wishing to optimize yield of the most commercially valuable parts.

(*Key words*: broiler yield, carcass aging, breast filet, chicken sex, chicken age)

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INTRODUCTION

Demands for high quality parts and further processed convenience foods have driven the poultry industry to change its marketing practices (Roenigk and Pedersen, 1987; Watts and Kennett, 1995). In 1970, 73% of US poultry was sold primarily in supermarkets as ready-to-cook whole carcasses, whereas 23% of the products were sold as cut-up parts (Watts and Kennett, 1995). By 1995, less than 10% of the poultry products sold in the US were whole carcasses, and the balance was sold as parts or further processed convenience foods in supermarkets and restaurants (NASS, 2000). Today, with the vast majority of poultry being marketed in this manner, yield of high value items such as breasts and boneless filets has become critical to processors.

Several factors have been shown to affect yield of parts. These factors include strain, sex, age, health, nutrition, live weight, length of feed withdrawal before processing, and carcass downgrading (McNally and Spicknall, 1949; Schmidt et al. 1964; Moran and Orr, 1969; Bouwkamp et al., 1973; Moran, 1977; Siegel et al., 1984). Early studies on broiler yield concentrated on nutritional requirements and management practices that maximized growth and minimized feed conversion (Edwards et al., 1956; Bornstein, 1970; Boomgaardt and Baker, 1973; Twinning et al., 1973). More recently, attention has focused on comparing eviscerated carcass yield and component parts in different broiler strains, particularly among fast growing strains (Merkley et al., 1980; Orr et al., 1984; Bilgili et al., 1992; Renden et al., 1992; Acar et al., 1991, 1993; Moran and Blake, 1993).

Poultry companies generally select the broiler strain, sex, and age at market that maximizes their profitability. Variation in specialty poultry products means that some processors are deboning broilers that have an average live weight in excess of 1 kg more than broilers processed for the "fast-food" market (Martin, 1995; Thornton, 1995). McNally and Spicknall (1949) were among the first researchers to investigate carcass yields as an estimate of trends and relationships among different commercial poultry markets. Crawley et al. (1980) and Brake et al. (1993) evaluated the effects of age at marketing on offal production for commercial broilers. Brake et al. (1993) also conducted regression analyses to describe the relationship between body weight and yield of edible broiler parts. These latter authors concluded that their study provided baseline information for the general pattern of yield in modern broilers. Sell (1988) provided information on commercial turkeys that showed that as market age increased, the proportion of breast meat decreased and the proportion of breast skin increased. Because it is important for the poultry product manufacturers to anticipate yield patterns over a wide range of market ages, the present study was conducted to determine the effects of market age, sex and postmortem aging duration on yield of broiler parts.

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MATERIALS AND METHODS

Birds

Five hundred Ross × Ross broiler chicks were hatched from commercially obtained eggs and were grown to market age under simulated commercial conditions. At 1 d of age, male and female chicks were randomly allocated together among 25 floor pens (20 birds per pen). A pen was treated as a replicate experimental unit. Birds consumed feed and water ad libitum until 10 h before processing when feed and water were removed.

Stunning and Slaughter

Birds were processed at 37, 39, 42, 44, 46, 49, and 51 d of age. On each processing day, 16 of the 20 birds from each of four pens were randomly selected and transported 0.8 km to a pilot plant processing facility. Broilers were electrically stunned, head to shank, in a brine stunner with a fixed voltage of 50 V AC for 10 s, with a variable current of approximately 33 mA. Immediately after stunning, broilers were transferred to restraining cones, and both carotid arteries and at least one jugular vein were manually severed with a knife. Broilers were bled for 90 s, scalded at 54.4 C for 120 s, and mechanically defeathered for 30 s. Feet were removed manually by severing the intratarsal joint. Carcasses were manually eviscerated, washed, and allowed to drip for 5 min. Sex of each bird was determined by visual examination of the gonads during evisceration.

Carcass Chilling, Cutting, and Deboning

Carcasses were tumble-chilled in ice slush for 30 min, allowed to drip for 5 min, and placed into groups of eight (two carcasses from each pen). Groups of carcasses were held on ice for 0, 2, 4, or 6 h before manual cut-up into forequarters and leg quarters, as described by Hudspeth et al. (1973). Forequarters were further cut into wings and half breasts with a knife by severing the wings from the forequarters at the proximal ends of the humeri. The whole breasts were then split using a circular knife. Boneless filets were prepared from each half breast by separating each pectoralis major from skin, pectoralis minor, sternum, and ribs. Leg quarters were further cut into thighs and drumsticks (Hudspeth et al., 1973). All cutting was performed by the same personnel for all replications of the experiment. Weights of intact carcasses prior to chilling and total weight of part classes (forequarters, wings, breasts, filets, thighs, and drumsticks) from each carcass were observed. Combined left and right yields of breasts, wings, thighs, drumsticks, and filets were calculated as a percentage of prechilled and postchilled carcass weights for each bird.

Statistical Analysis

Percentage yield data were analyzed by ANOVA using replicates, ages, postmortem aging times, sexes, and carcass weights prior to chilling within ages as main effects. All first order interactions were tested for statistical significance ($P \leq 0.05$) using the error mean squares. Because no significant replicate or interaction effects were detected, the analysis was repeated after pooling the data over replicates and main effects. Main effect means were calculated and separated using Duncan's multiple-range test ($P \leq 0.05$) (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Age Effects

Effects of birds' age on yield of parts is shown in Table 1. No consistent age-related yield pattern for wings or drumsticks was detected, but yields of thighs, forequarters, breasts, and filets increased as slaughter age increased, especially after 42 d. This trend no doubt reflects growth of muscular tissue as the birds mature. In the study by Hudspeth et al. (1973) using commercially processed broilers of unstated but uniform age, piece weights were regressed on chilled carcass weights. Their regression coefficients were positive and generally greater for those pieces that exhibited more muscle tissue than for bonier pieces. For example, the coefficients for split breast, thigh with back portion, and whole leg with back were 0.168, 0.150, and 0.243, respectively, whereas for bonier parts such as drumstick and wings, the coefficients were much lower (0.084 and 0.067, respectively). Apparently, this trend toward higher yields of meatier parts as birds grow heavier applies to birds whose carcass weights vary because of market age as well.

Sex Effects

Effects of the birds' sex on yield of parts is shown in Table 2. Females yielded larger proportions of forequarters, breasts, and filets but smaller proportions of drumsticks than males. Effects of carcass weights within age on percentage yield were not statistically significant for any of these cuts, so these differences reflect true sex effects and not weight differences associated with sex. Yield of wings was not significantly affected by sex per se, but carcass weight within age was significant. The reason percentage yield of wings was statistically significant is unclear. The effect was not sufficiently great to result in a significant difference in wing yield between male and female birds even though carcass weights within ages of the former tended to be greater than those of the latter.

Postmortem Aging Effects

Effects of postmortem aging time on yield of parts are shown in Table 3. Zero aging times resulted in significantly higher yields of forequarters and breasts compared to 2 h aging times. Yield of drumsticks aged 0 h postmortem was equivalent to those aged 2 h but was significantly greater than those aged 4 h or more. Yield of thighs was somewhat inconsistent, exhibiting a significantly small, but inexplicable, decrease at 2 h aging compared to other aging periods.

TABLE 1. Effects of age on yield of parts as a percentage of prechilled broiler carcass weight

Age	n	Thighs	Forequarters[1]	Wings	Breasts[2]	Drumsticks	Filets[3]
(d)		(%)					
37	64	33.1^{b}	53.6^{c}	13.2^{a}	40.6^{b}	15.4^{bc}	14.3^{b}
39	64	32.7^{b}	53.8^{c}	13.0^{ab}	41.3^{b}	15.3^{bc}	14.7^{ab}
42	64	32.7^{b}	54.3^{c}	12.9^{ab}	41.3^{b}	15.2^{c}	15.2^{a}
44	64	34.5^{a}	55.8^{b}	12.7^{b}	42.6^{a}	15.9^{ab}	15.2^{a}
46	64	35.1^{a}	55.8^{b}	12.9^{ab}	42.7^{a}	16.4^{a}	14.9^{ab}
49	64	34.6^{a}	55.7^{b}	12.9^{ab}	42.7^{a}	15.6^{bc}	15.2^{a}
51	64	35.6^{a}	56.9^{a}	13.1^{a}	43.6^{a}	15.7^{bc}	15.2^{a}
SEM		0.14	0.13	0.04	0.13	0.09	0.08

[a–c]Means in the same column bearing no common superscripts differ significantly ($P \leq 0.05$).

[1]Breast quarters with adherent skin, wing, and bone.

[2]Breast quarters with adherent skin and bone, wing removed.

[3]Boneless, skinless pectoralis major.

TABLE 2. Effect of sex on yield of parts as a percentage of prechilled broiler carcass weight

Sex	n	Thighs	Forequarters[1]	Wings	Breasts[2]	Drumsticks	Filets[3]
		(%)					
Male	135	34.0^{a}	54.5^{b}	12.9^{a}	41.7^{b}	15.9^{a}	14.7^{b}
Female	89	34.1^{a}	56.1^{a}	13.1^{a}	42.8^{a}	15.3^{b}	15.3^{a}
SEM		0.14	0.13	0.04	0.13	0.09	0.08

[a,b]Means in the same column bearing no common superscripts differ significantly ($P \leq 0.05$).

[1]Breast quarters with adherent skin, wing, and bone.

[2]Breast quarters with adherent skin and bone, wing removed.

[3]Boneless, skinless pectoralis major.

TABLE 3. Effect of postmortem aging time on yield of parts as a percentage of prechilled weight by broiler carcasses

Postmortem aging time	n	Thigh	Forequarter[1]	Wing	Breast[2]	Drumstick	Filet[3]
(h)		(%)					
0	112	34.2^{a}	56.0^{a}	13.2^{a}	42.9^{a}	16.0^{a}	15.1^{a}
2	112	33.1^{b}	55.2^{b}	13.0^{a}	42.1^{b}	15.7^{ab}	15.0^{a}
4	112	34.2^{a}	55.0^{b}	13.0^{a}	42.0^{b}	15.5^{b}	14.9^{a}
6	112	34.7^{a}	54.3^{c}	12.8^{a}	41.5^{b}	15.4^{b}	14.9^{a}
SEM		0.14	0.13	0.04	0.13	0.09	0.08

[a–c]Means in the same column bearing no common superscripts differ significantly ($P \leq 0.05$).

[1]Breast quarters with adherent skin, wing, and bone.

[2]Breast quarters with adherent skin and bone, wing removed.

[3]Boneless, skinless pectoralis major.

TABLE 4. Effect of postmortem aging time on yield of parts as a percentage of postchilled weight by broiler carcasses

Postmortem aging time	n	Thigh	Forequarter[1]	Wing	Breast[2]	Drumstick	Filet[3]
(h)		(%)					
0	112	31.8^{a}	52.0^{a}	12.2^{a}	39.8^{a}	14.9^{a}	13.9^{a}
2	112	31.0^{b}	51.7^{a}	12.1^{ab}	39.4^{a}	14.5^{ab}	14.0^{a}
4	112	31.5^{ab}	50.7^{b}	11.9^{bc}	38.6^{b}	14.5^{ab}	13.9^{a}
6	112	31.9^{a}	50.0^{b}	11.8^{c}	38.2^{b}	14.1^{b}	13.7^{a}
SEM		0.13	0.15	0.05	0.13	0.07	0.08

[a,b]Means in the same column bearing no common superscripts differ significantly ($P \leq 0.05$).

[1]Breast quarters with adherent skin, wing, and bone.

[2]Breast quarters with adherent skin and bone, wing removed.

[3]Boneless, skinless pectoralis major.

Yield of filets was very consistent regardless of aging time (14.9 to 15.1%), and no significant postmortem aging effects on filet yield were detected. This increase in yield of parts from carcasses aged only a few h postmortem reflects, at least in part, the well-documented superior moisture binding properties after chilling of pre- and peririgor muscle compared to postrigor meat (Hamm, 1960; Honikel et al., 1981; Lyon et al., 1984; Lyon and Wilson, 1986; Young, et al., 1989), because the yield calculations data are based on prechilled carcass weights; however, if the yield of parts is expressed as a percentage of postchilled weights (Table 4), yields of forequarters from carcasses aged 2 h or less remain greater than those of carcasses aged 4 or 6 h. There is no obvious explanation for this observation, but it is possible that the breast portion absorbs and retains more moisture than do other parts. Because fillet yields were unaffected by aging time, the ability to retain the absorbed moisture is not carried through to deboning. This possibility needs further study.

Based on the results of this study, the following conclusions are drawn:

1. Percentage yields of meatier broiler parts increase as the birds age, at least during the rearing period covered in this study.
2. Carcasses of female broilers produce higher percentage yields of forequarters, breasts, and filets, but lower yields of drumsticks, than those of male broilers.
3. Yields of forequarters, breasts, and drumsticks are enhanced if postmortem aging times are limited to 2 h or less.
4. These effects of age, sex, and postmortem aging duration on yield of parts are independent of one another.

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